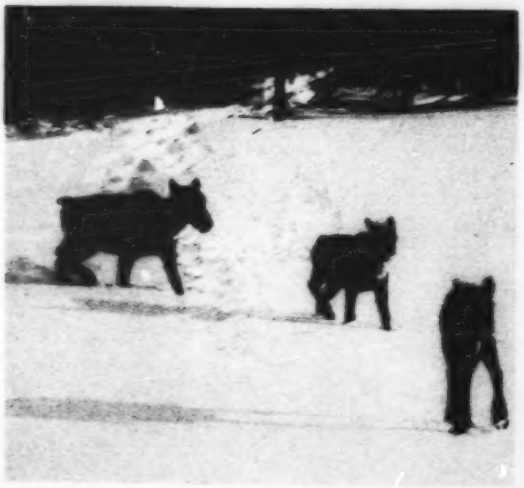
Pukaskwa National Park



Natural Resource Conservation

Environment Canada

Parks Service

OIL SPILL INFORMATION
TAILORED TO THE SHORELINE ENVIRON OF
PUKASKWA NATIONAL PARK

for

Warden Jennie Sparkes
Resource Conservation

Pukaskwa National Park
Heron Bay, Ontario

by:
Anne Young
Water Quality
Summer Co-op Student

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91-05907/

SUMMARY

This report has been compiled to collect information about oil products as it would relate to Pukaskwa National Park in the event of an offshore spill.

The first section of this paper deals with some physical properties of oil. Many types of oils can be derived from petroleum. The oils which are shipped past the Park's shoreline are gasoline, diesel fuel oil, light heating oil and Bunker C. Therefore, these are the only oils that the Park has to be concerned with.

Background information about oil is provided. Specific gravity, viscosity, pour point, flash point, surface tension, solubility and weathering will affect the behaviour of oil on the water at the shoreline and how it can be cleaned up. Although not an objective, this section was included to ensure the rest of the research paper could be fully understood.

The following sections explain shoreline sensitivity, effects on wildlife, containment, recovery and monitoring in terms of oil spills. Shoreline sensitivity is determined by the shoreline material, the surrounding energy level and any unique features which may be present. As far as wildlife is concerned, an oil spill can take a large toll on aquatic invertebrates, water birds and fish. The aromatic hydrocarbon component of the oil is responsible for many of these deaths and physiological symptoms. Containment booms play an integral part in oil spill cleanup. There are important points to remember in boom selection and these are outlined in this report. The Park is [redacted] have easy access to [redacted] as containment barriers.

The oil recovery methods discussed are skimmers, sorbents and manual recovery. Since sorbents were an objective, a large fold out comparison chart explains them in detail.

There is no feasible methodology for the chemical analysis of residual impact; however, since oil spills do have a large impact on aquatic organisms, these can be monitored after a spill. A physical analysis would be just as effective as a chemical analysis and this is explained.

A number of conclusions have been drawn as a result of this research paper. Two main conclusions are: that Park employees can have the capability to mitigate any small oil spills that have the potential to occur within the Park; and that Park employees have the capability to protect Park priority areas if an off shore vessel were to have an oil spill.

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1.0 INTRODUCTION

1.1 Background

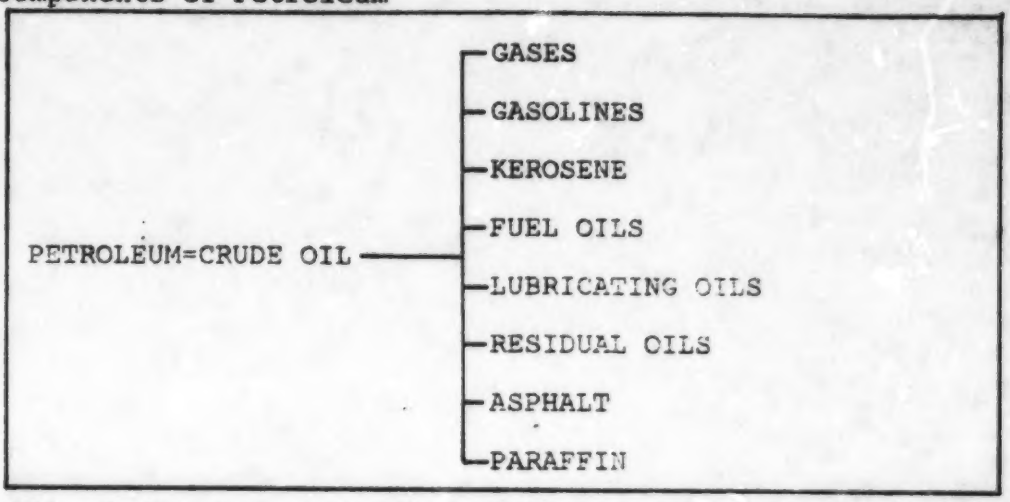
An oil spill off the shores of Pukaskwa National Park may seem highly unlikely, but is quite possible. During the shipping season, which generally runs from the beginning of April to the end of December, four petroleum products are regularly shipped past the Park's coastline. Bunker C is shipped into the mill in Marathon and gasoline, diesel fuel oil and light heating oil are shipped into Thunder Bay. The Park itself deals regularly with fuels such as gasoline, diesel fuel oil and Jet B fuel.

If an oil spill were to occur off the coast of Pukaskwa National Park there would be a high potential for shoreline contamination. If Park staff had a reasonable understanding of oils, how they behave on water, the effects they would have on the shoreline and appropriate cleanup measures ahead of time, the potential impact of a spill could be reduced and response operations would be much more effective.

Sufficient freshwater oil spill information was available from numerous agencies and most of it was easily tailored to the shoreline environ of Pukaskwa National Park. Two of the many sources which proved quite useful were The Basics of Oil Spill Cleanup With Particular Reference to Southern Canada by Mervin F. Fingas et al. and "Coastal Environments and the Clean up of Oil Spills for Inland Waters" which was prepared for the Environmental Protection Service, Environment Canada by Woodward-Clyde Consultants. Some marine (salt water) references applied to freshwater situations as well.

At the onset, some distinctions should be made. In this research paper the words "petroleum" and "oil" have specific meanings which are clarified in Chart 1.

Chart 1 Components of Petroleum



All of the above are oils and they are listed in order from the lightest oil to the heaviest oil. Gasolines, kerosene and the lighter fuel oils, such as diesel fuel, are sometimes referred to as "light oils". The word oil in itself is used as a general reference to all or any of the above listed oils.

1.1 Purpose

The purpose of this report is to provide Park staff with a quick reference guide to aid in the response to oil spills off shore of Pukaskwa National Park.

1.2 Objectives

1.2.1 Research oil spill information currently available from other agencies and tailor it to the shoreline environ of Pukaskwa National Park.

1.2.2 Provide information about oil properties, shoreline sensitivity, effects on wildlife, containment, recovery and impact monitoring.

1.2.3 Facilitate the decision making process which is necessary for deciding on methods to be used for shoreline protection.

1.2.4 Provide contacts for assistance with oil spill response.

1.2.5 Identify sensitive shoreline areas and prioritize them with respect to oil spill response.

1.2.6 Provide contacts for assistance with oil spill response.

1.2.7 Address containment and recovery.

1.2.8 Provide a list of sorbent suppliers and costs.

2.0 DISCUSSION ON OIL

Petroleum is actually a complex mixture of hydrocarbons. Crude oils are composed of around 98% hydrogen and carbon and can contain as many as 300 different compounds; the exact amount varies according to the location from which the oil was taken. The consistency of crude can vary from a light volatile fluid to a fairly viscous semi-solid material. The refined products are virtually 100% hydrogen and carbon and are produced by catalytic cracking and fractional distillation. The properties of some of oil refinery products are explained in the following sections.

2.1 Properties Which Influence Oil Behavior

The Park should be concerned with four types of oil: gasoline, diesel fuel oil (No. 2 fuel oil), light heating oil (No. 4 fuel oil) and Bunker C (No. 6 fuel oil). These oils have different physical properties which are compared in this section. Jet B (aviation gas) is also a concern but it is only held distinct in the following comparisons because its physical properties are slightly different than that of gasoline. The properties which distinguish gasoline and Jet B do not necessitate a difference in treatment. Table 1 compares the specific gravity, viscosity, pour point and flash point of the different oils.

Table 1 Comparison of Properties for Five Oils

Properties	Gasoline	Jet Fuel	No.2 Oil	No.4 Oil	No.6 Oil
Specific Gravity	0.65-0.75	0.8	0.85	0.9	0.98
Viscosity cs (38° C)	4-10	1.5	15	50	300-3000
Pour Point ° C	n/a	-40	-20	-10	2
Flash Point ° C	-40	55	55	60	80

(Source: The Basics of Oil Spill Cleanup With Particular Reference to Southern Canada. M. Fingas et al. 1978)

2.1.1 Specific Gravity

The specific gravity of oil is normally less than 1.0; however, as oil weathers over a period of time the more volatile fractions will evaporate leaving behind an oil that has higher specific gravity. Once the specific gravity is past 1.0 the oil will sink below the surface of the water body.

2.1.2 Viscosity

Viscosity influences the spreading rate of the slick, the stickiness of the oil, the penetration of oil into beach sediments and the ability of pumps to remove oil from the water surface.

2.1.3 Pour Point

The pour point influences the amount of impact. If the temperature is below the pour point the oil will have a semi-solid consistency and it would only penetrate the beach material if the material is coarse or if the ambient temperature was high. If the temperature was above the pour point, the oil would be a free flowing fluid and it would rapidly penetrate most granular beach substrate. This means Bunker C may become a thick semi-solid once its temperature lowers to lake water temperature and gasoline would remain a liquid.

2.1.4 Flash Point

The flash point is an important safety factor in cleanup operations. For instance, gasoline is a serious fire hazard as it has a low flash point and Bunker C is not a serious fire hazard as it has a comparatively high flash point.

2.1.5 Surface Tension

Surface tension will influence the rate of spread. As the surface tension decreases there is an increase in the potential spreading rate of the oil. The rate of spread can also be influenced by temperature, since an increase in temperature will cause a decrease in the surface tension, which in turn causes the slick spreading rate to increase.

2.1.6 Solubility

At less than five parts per million, the solubility of oil in water is very low. The solubility "would be approximately equivalent to one grain out of a teaspoon of sugar dissolving in a cup of water". (Basics of Oil Spill Cleanup With Particular Reference to Southern Canada. Fingas et al. p. 19) This is not to say that this small fraction should be ignored as a small fraction is all it takes to toxify aquatic organisms (see Figure 3).

2.1.7 Weathering

Weathering is defined by M. Fingas as "the loss of certain components of the oil through a series of natural processes which begin when the spill occurs and continues indefinitely while oil remains in the environment" or essentially, until the oil is reduced to little balls of tar. These processes are mainly evaporation, dissolution, oxidation, emulsification and microbial degradation. Weathering starts immediately after a spill and occurs along with the spreading of the slick. The rate of weathering is not consistent throughout the spill and is usually at its highest during the first few hours after the spill. The weathering rate is also largely determined by the type of oil spilled. Contrary to the heavier oils, the lighter oils have a very large percentage of highly volatile and light components which are lost quite rapidly to the natural processes mentioned above.

The details of the natural processes involved in weathering are highly involved and beyond the scope of this report, but they do deserve a brief discussion as they are highly related to oil behavior and also to one another.

2.1.7.1 Evaporation

The evaporation rate is determined by the volatility of the different compounds within the spilled oil, air temperature, water temperature, water turbulence, wind and the spreading rate of the slick. The most volatile compounds evaporate off first and then the rate of evaporation gradually decreases creating a residue of a higher specific gravity and viscosity. Naturally, if the specific gravity rises above 1.0 the oil will sink.

Gasoline and lighter fuel oil slicks evaporate almost completely after 24 hours, whereas Bunker C will persist over time.

2.1.7.2 Oxidation and Dissolution

During oxidation and microbial degradation, some hydrocarbons within the oil will undergo chemical reactions producing sulphur compounds, salts and smaller compounds which are water soluble. This dissolution process occurs throughout the whole weathering process.

As stated, the combination of hydrocarbons with oxygen can produce other compounds which are water soluble. Some of the resulting products may also act as emulsifiers and increase the natural dispersion rate of some of the remaining oil.

Oxidation can also be aided by ultraviolet radiation especially if the slick film is relatively thin.

2.1.7.3 Emulsification

Emulsification can mean two different things. It can mean mini oil droplets in water as a result of wave action or it can mean droplets of water in oil which forms a consistency like (and is referred to as) chocolate mousse. Chocolate mousse does not always form in all cases of emulsification, however, the tendency for it to happen is greater with Bunker C. Once chocolate mousse reaches the shoreline, it tends to resist further weathering.

2.1.7.4 Biodegredation

Biodegradation depends mainly on the temperature of the water and oil mixture: micro-organisms are attacking the oil that has direct contact with the water. This process is limited by temperature and the amount of nitrogen and phosphorous containing nutrients. Since Lake Superior is an oligotrophic lake and relatively low in nutrients, this process would occur at a comparatively slower rate than in eutrophic lakes. The specific gravity increases during this process as lighter components are degraded first.

2.2 Oil Spreading Mechanics

As it is commonly known, oil spilled on water tends to spread out into a slick. Oil will spread over the water surface due to the gravitational force and surface tension of the water, which usually has a greater surface tension than the oil mass. Therefore, in the absence of wind and water currents, the oil will still spread. Nonetheless, oil movement is highly influenced by winds and currents, of which there are plenty off the shores of Pukaskwa National Park. Figure 1 illustrates the general surface currents on Lake Superior. Slicks tend to move in the same direction

and at the same speed as the surface water and they also have been found to move at a speed of three percent of the wind velocity. As with other processes, the type of oil spilled has a great influence on the spreading rate as the more viscous the oil, the slower it will spread.

Another interesting feature which has a great influence on spread direction is the Coriolis effect. This effect is well described by M. Fingas et al. "Due to the earth's rotation, movement of the slick in the Northern Hemisphere is slightly to the right of the wind direction." Figure 2 explains how the Coriolis effect would affect an oil spill off the shores of Pukaskwa.

2.2.1 Weather Information

Weather forcasts can give an indication of potential slick movement.Forcasts are essential for the Park staff in deciding if and which important sections of Park shoreline could be protected from the slick ahead of time in order to mitigate shoreline contamination.

For weather forcasts up to 36 hours contact the following:

Lake Superior East

Sault Ste. Marie Weather Office
Atmospheric Environment Services
R.R.#1 Sault Ste. Marie, Ontario
P6A 5K6
(705) 779-3144

Lake Superior West

Thunder Bay Weather Office
Atmospheric Environment Services
104 Princess Street
Thunder Bay, Ontario
P7E 3N9

For wind and wave forcasts and current information contact the Canadian Coast Guard in Thunder Bay.

C.C.G.S. Radio Station
244 Lincoln Street
Thunder Bay, Ontario
P7B 5L2
(807) 345-5190

Pukaskwa National Park is presently submitting a capital project proposal for the development of Park weather stations in cooperation with the Atmospheric

Figure 1 Surface Currents of Lake Superior
(Source: Coastal Unit Plan, p.10)

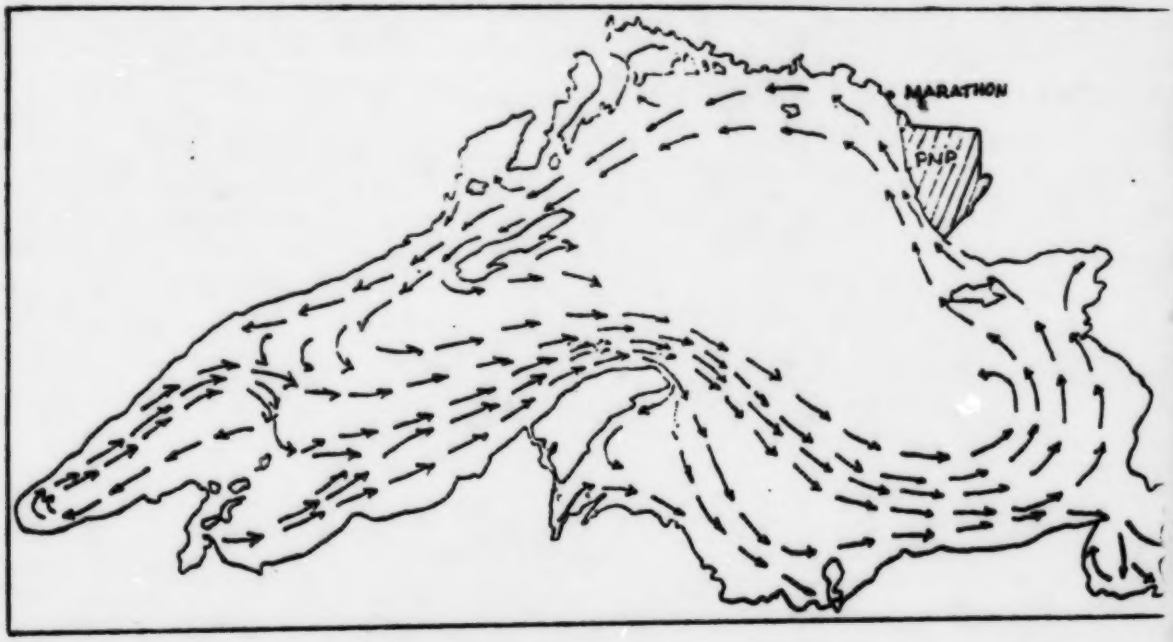
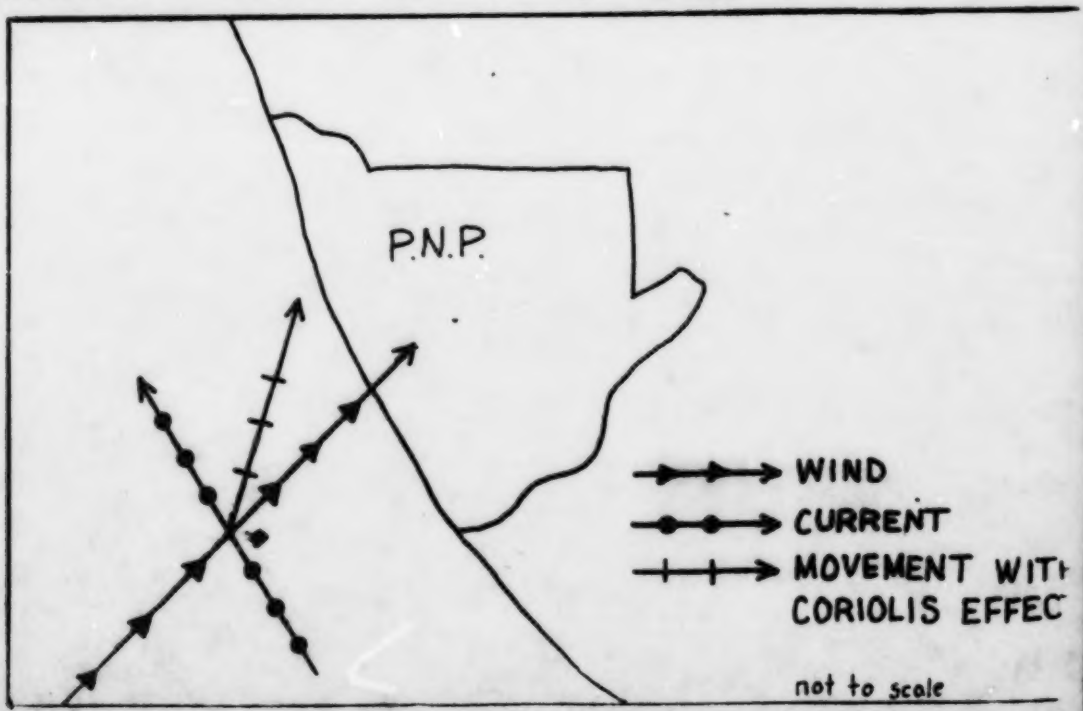


Figure 2 Hypothetical Movement of Oil From a Point Off Shore of Pukaskwa National Park Showing Coriolis Effect. (Source: The Basics of Oil Spill Cleanup With Particular Reference to Southern Canada. Fingas et al. (p. 25).



Environment Service. This "Remote Weather Network" is planned to consist of one portable summer station and three (3) fully automated, remote weather stations, one of which is to be located near the Park shoreline. If this project materializes, both the remote weather station on the coast and the portable weather station would greatly facilitate slick movement forcasting.

3.0 SHORELINE SENSITIVITY

If a spill were to occur off the shores of Pukaskwa National Park, there would be a good chance that oil would reach the shoreline. Therefore, in order for contingency planning to be effective, it is important to have an assessment of shoreline sensitivity. This would provide an idea of the amount of persistence and impact that would have to be dealt with in the event of an oil spill. Chart 2 shows several key words which are commonly used to describe or classify a shoreline.

Chart 2 IMPORTANT WORDS FOR SHORELINE CLASSIFICATION

Substrate *	Exposure	Energy Level
mud	sheltered	high
sand	exposed	low
gravel		
cobble	Access	Unique Features
boulder	land	biological
marsh	water	physical
dune	air	cultural
rock cliff	none	recreational
rock platform		none
man-made structure		

Width of shoreline is also important.

Pukaskwa National Park has many unique features along its shoreline which would be quite sensitive to oil. Virtually the whole Park shoreline is sensitive in one way or another but protection of long sections of shoreline is impossible due to the limited availability of equipment and resources and the lack of feasibility. Therefore, shoreline protection priorities have to be drawn ahead of time. There are many sensitive areas. Some have been highlighted in Table 2 due to special circumstances and these are prioritized into three (3) National Park priority classes. The highlighted areas are also identified in Appendix I.

Table 2 Sensitive Shoreline Areas

Location	Reasons	Priority Level
Beach Two	12	1
Beach One	12	1
Horseshoe Beach and Area	7, 12	1
Hattie Cove	1, 3, 5, 11, 12, 13	1
Playter Harbour	5	3
Mouth of White River	3, 6	1
Mouth of Willow River	3, 5	1
Shot Watch Cove	4	2
Morrison Harbour (1km N.)	3, 5	1
Island between Morrison Harbour and Fish Harbour	8	2
Fish Harbour	3, 5	1
Oiseau Bay	3, 4, 5, 7, 9, 10	1
Dampier Cove	5	3
Nicols Cove	5	3
Fisherman's Cove	3, 5	1
Island west of One Lake Island	8	2
White Gravel River Beach Area	3, 5	1
White Spruce Harbour	3, 5	1
Simons Harbour	4, 5, 6, 9	2
Mouth of North Swallow River	1, 2, 3	1
Island off Trappers Harbour	8	2
Triangle Harbour	13	2
Otter Cove	4, 6, 13, 14	2
Otter Island and surrounding islands	2, 8, 15, 16	2
Island off Deep Harbour	9	2

Legend for Reasons

1. Entrance to Coastal Hiking Trail (CHT)
2. Pukaskwa Pits
3. Campsite area
4. Trappers' cabins
5. CHT located on or near shoreline
6. Common sailboat mooring area
7. Rare plants
8. Herring gull colony
9. Great blue heron colony
10. Ring-bill gulls sighted (may become established in future)
11. Water intake location
12. Day use area
13. Highly sheltered, oil would persist
14. Warden station
15. Caribou project location
16. Lighthouse location

Legend for Priority Level

1. Public/staff safety
2. Management concern
3. Aesthetic concern

3.1 Shoreline Material and Penetration

The coarseness of the substrate material determines how deep the oil will penetrate into the ground at the shoreline. With fine sand, only very light oils such as gasoline and diesel fuel can penetrate deeply. Heavy Bunker C oil does not penetrate deeply. For pebble and cobble beaches, the penetration is equal to or greater than one metre in depth for most oils including Bunker C. A detailed description of shoreline types, impact and persistence is located in Appendix II.

The Pukaskwa National Park shoreline can be divided into basically five coarseness categories which are rock, boulders, cobbles, gravel and sand. The order of sensitivity for these materials is shown in Chart 3.

Chart 3 Sensitivity - Particle Size

*sand	most sensitive
*gravel	↓
*cobble	
*boulder	
*rock	least sensitive

There are three rules of thumb concerning penetration depth:

1. Penetration depth increases as particle size increases.
2. As penetration depth increases, the ability of waves to abrade and remove oil decreases.
3. As penetration depth increases, cleanup difficulties increase.

Three other items which affect penetration depth are oil viscosity, temperature and the length of time the shoreline is exposed to the oil.

3.2 Coastal Exposure

Coastal exposure is one way that the amount of persistence the oil will have on the shoreline can be determined. Oil on a straight, open shoreline will have a minimum of persistence (i.e. days or weeks) whereas oil on an indented sheltered shoreline can persist as long as decades. The park has both open and straight shorelines. Chart 4 shows the order of sensitivity for levels of coastal exposure.

Chart 4 Sensitivity - Coastal Exposure

*sheltered environments and pocket beaches	most sensitive
*exposed beaches and sand flats	↓
*exposed rock or cliff shorelines	least sensitive

3.3 Wave Energy Level

The energy level at the shoreline influences the accumulation and the persistence of the spilled oil. The wave energy level depends on the distance along the open water over which the wind blows (fetch), wind direction, whether the coast is straight or indented and if there is offshore ice or not.

If the energy level is low at the shoreline or if the lake is calm, oil will accumulate into thick layers at the edge of the water. If the energy level is high at the shoreline or if the lake is rough, the oil will spread over a longer area of shoreline. More of it will disperse into the water column and therefore it will weather at a quicker rate. As a matter of fact, rocky, steep, unsheltered shorelines with heavy wave action are considered to be self-cleaning shorelines as the bulk of oil spilled is usually gone within a few weeks.

For sheltered and sandy environments it is much different. The oil becomes stranded and can remain there for years. Oil that seeps through the substrate or gets buried under the sand from wave action is not exposed to oxygen or sunlight. It will not weather and will remain there unchanged for up to decades.

3.4 Accessibility

Most of these shorelines are quite limited in accessibility in that they can only be reached by boat, water compatible aircraft or by foot. As a result, cleanup actions would be severely limited.

4.0 EFFECTS OF OIL ON SMALL WATER ORGANISMS

Studies have shown that oil definitely has an effect on organisms living in the water in which the oil is spilled. The organisms which are about to be discussed are not necessarily found along the whole length of the shoreline but if oil is spilled where they are located they will certainly be affected.

The following is a description of what happens to the smaller organisms. Even though there is only a small percentage of water soluble components such as aromatics within the oil, they are lethal enough to directly toxify the organisms mentioned below. Concentrations of dissolved petroleum hydrocarbons lethal to most zooplankton range from 0.1 to 10 mg/L (Trudel, 1985). Studies have shown that surface insects are completely eliminated, zoobenthos, zooplankton and protozoan populations are reduced and protozooplankton are altered. If there are any components of the oil which are heavier than the water, they will sink and form a sludge on the bottom blocking the oxygen supply for the bottom dwelling organisms. The aquatic insects and crustaceans which

breathe from the surface are reduced also as their oxygen supply is immediately cut off by the oil slick on top of the water. Laboratory experiments have found that fungi populations are generally higher after an oil addition and bacteria are increased at times due to the increased amount of available carbon but not to such an extent that it can be easily measured and compared to a benchmark. There is little or no effect on phytoplankton, periphyton, or aqueous nutrients. Fortunately, the above mentioned biological components which are affected do have the ability as populations to recover with time; however, it should be known that even though the biomass of the zooplankton builds up throughout the summer in Lake Superior, they only have a few generations per year. Therefore, in the event of a major spill, their population could be severely reduced.

5.0 EFFECTS OF OIL ON BIRDS

Birds which are immediately affected by an oil spill are diving birds and birds which feed out of the water. First the oil destroys the insulating properties of the bird's feathers. Then the bird inevitably manages to ingest oil either while trying to preen it out of its feathers or while eating food. The toxic components can also be absorbed through the skin. If the bird is incubating eggs, the eggs will also be contacted with oil bearing an effect on the embryos inside. The symptoms of oil contamination are listed in Table 3.

5.1 Additional Comments

It should be noted that it is very difficult to rehabilitate oiled birds successfully and that some species are easier to rehabilitate than others. There are several recommendations and procedures for the treatment of oiled birds and an example is included in this report in Appendix III.

It should also be noted that in the colder temperatures of Pukaskwa National Park, oil would take longer to weather down to tar balls. Therefore, oiled birds would potentially be a bigger problem in this area.

For professional assistance contact the following biologist:

Jenette Perkins
Biologist
Canadian Wildlife Service
1325 Woodward Drive
Ottawa, Ontario
K1G 3Z7
(613) 952-2299

Table 3 Symptoms of Oil Contamination for Birds

Symptoms Exhibited By Adult Birds
*hyperphagia (excessive intake of food) ┐ *mortality *adrenal hypertrophy *deterioration of lymphatic system ┘ combined with cold *structural lesions of the red blood cells *severe distortions of cell shape *plasma membrane crenulation *mineralization of mitochondria *abnormally high or low cytoplasmic density *histological lesions in liver, spleen, kidney and bone marrow *immunosuppression suggested *longer time length to complete reproductive cycles *egg hatchability lowered
Symptoms Exhibited By Embryo
***mortality (do not hatch) *low embryonic body weight *reduced crown to rump length and bill length *extreme stunting *eye, brain and bill defects *incomplete formation of bone Embryo toxicity is dependent on the aromatic hydrocarbon content of the oil and takes place when the aromatic hydrocarbons pass through the shell and membrane to the embryo. Even if less than 10 percent of the egg gets coated, hatching is lowered and growth is stunted.**

6.0 EFFECTS OF OIL ON FISH

Fish eggs and larva are more sensitive to hydrocarbons than adult fish as in these states, fish do not yet have the ability to avoid the oil contaminated water. The main symptoms they suffer from at these stages are death, loss of buoyancy, reduced feeding and swimming ability and reduced size at hatching. Figure 3 shows mortality rates for embryo-larval stages of fish with continuous exposure to different hydrocarbon concentrations.

There are some cobble areas along the shoreline of Pukaskwa National Park which could be Lake Trout spawning beds. If this is the case, some Lake Trout crops could be lost due to the fact that hydrocarbons from oil spills tend to accumulate at the cobble (sediment) - water interface where the Lake Trout eggs are laid. Following, is a contact for information concerning fish rehabilitation programs and whether one would be necessary.

Environmental Emergencies Technology Division
Environmental Protection Service
Environment Canada
Edmonton, Alberta T6B 2X3

Since adult fish have the ability to avoid contaminated water, most of the symptoms they will exhibit are minor and often short term and reversible. The symptoms have been listed in Table 4.

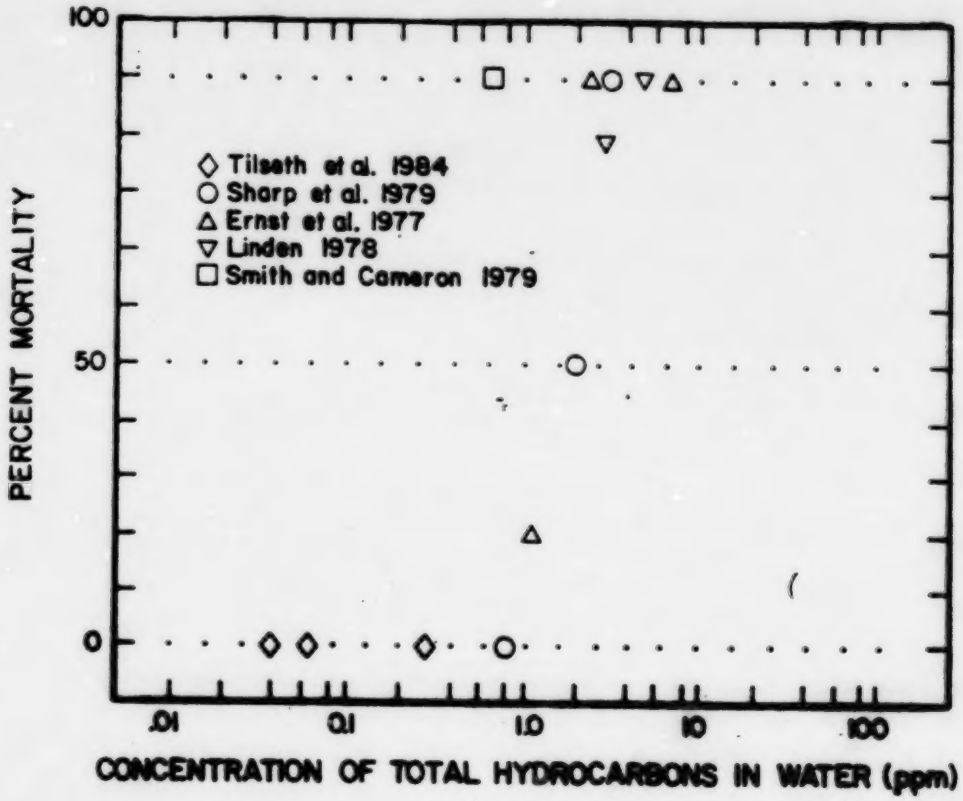
Table 4 Symptoms of Adult Fish

Symptoms Exhibited by Adult Fish
*increased respiratory rate
*elevated serum glucose levels
*disruption of growth
*liver necrosis
*gill damage
*necrosis of intestinal mucosa
*pancreatic necrosis
*renal damage
*necrosis of olfactory and taste organs
*muscle degeneration
*changes in fin pathology

In some situations, oil can adhere to the fish gill surface. Fish will react to this by hypersecreting mucous which in turn leads to respiratory distress and possible asphyxiation.

There are situations where the presence of hydrocarbons can be lethal to fish. Some are unfortunate enough to get into a situation where they cannot avoid the oil, such as in confined bays and estuaries. Also, there can be physiological and environmental influences in the form of stresses which were being experienced prior to the spill such as lack of food and parasitism.

Figure 3 Sensitivity of the embryo - larval stages of fish to water - soluble fractions of crude and refined products under conditions of continuous exposure. (Source: Coastal Environments and the Cleanup of Oil Spills for Inland Waters. Woodward - Clyde Consultants.)



7.0 CONTAINMENT BOOMS

In most cases, containment booms are the first equipment mobilized after a spill and the last to be removed. Commercial floating booms have basically three uses: they enclose the oil slick, protect specific areas and they divert oil to recovery areas. Figure 4 shows the basic structure and parts of the boom.

The freeboard prevents waves from washing the oil over top, the skirt prevents oil from being swept underneath and the boom is tensioned and weighted so it can remain perpendicular in the wind, waves and current.

There is a publication which was prepared by S.L. Ross Environmental Research Limited for Environment Canada which addresses all the different types of containment booms available. This publication is titled A Catalogue of Oil Spill Containment Barriers and it is now available in the Pukaskwa National Park library as an excellent reference book about the different types of barriers, who manufactures them and the specifications and operational data for each. Information such as costs and limitations are also shown for each type of boom. According to this catalogue, 105 manufacturers have developed a total of at least 138 different booms. Forty-six of the 105 manufacturers have developed their booms beyond the prototype stage with 77 different booms being or having been marketed commercially.

There are obviously many different booms to select from. It would probably narrow things down a bit if one keeps the following things in mind when choosing a boom.

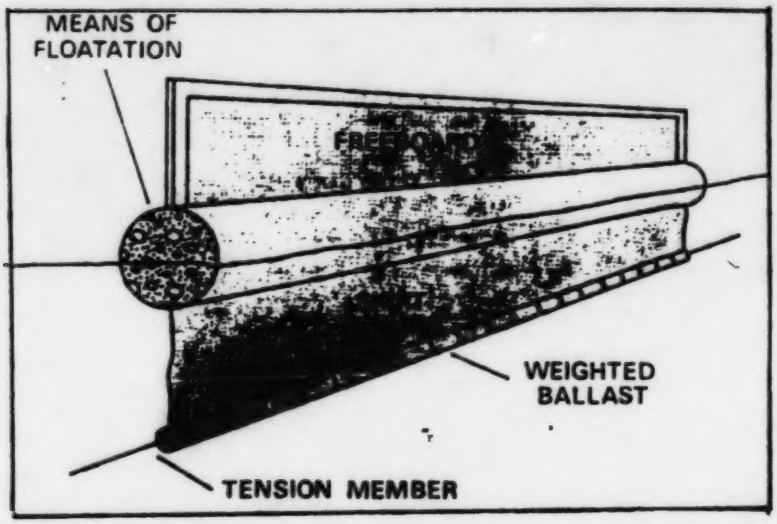
7.1 Points To Remember In Boom Selection

*the greater the amount of floatation material, the greater the ability of the boom to withstand waves
*as the skirt deepens, water and currents will exert a larger effect
*as the freeboard gets higher, wind will have a greater effect
*for Lake Superior, a tension member should be considered for practicality
*anchor points should be close enough together to put the load onto the tension members and not the skirt i.e. less than 30 metres apart
*floating booms with deeper skirts always require more ballast at the lower edge

7.2 Special Situation

Another barrier which is quite effective, especially for containing Bunker C spills, is the very simple boom@log. Interviews with both Mr. Harry Whittaker, Head of Engineering, Environment Canada and Mr. Dennis Michano, marine equipment officer, Pukaskwa National Park, provided

Figure 4 Basic components of a floating boom. (Source: Basics of Oil Spill Cleanup With Particular Reference to Southern Canada. Fingas et al. 1978.)



useful information concerning Bunker C containment with boom logs.

Boom logs contain Bunker C most effectively if they are tied together right next to each other and they are an effective barrier in both calm and choppy water. Three examples of how they can be used are: to protect small islands by surrounding them with a boom log ring and anchoring it at the upwind side, to protect inlets by tying the boom logs to points at either end and to contain oil at the vessel from which it is leaking.

If a Bunker C spill were to occur off the coast and the Park was prepared for fast mobilization, in some instances and locations most oil could be contained with boom logs before it reached the shoreline. Figure 5 should help staff decide how to set up boom logs in different situations.

7.3 Other Barriers

There are other types of barriers such as sorbent, airstream, water stream, bubble and chemical barriers but they are not suitable for use on Lake Superior. Their impracticability makes them unsuitable for further discussion.

8.0 RECOVERY OF OIL

Oil can be recovered using several methods, three of which are skimmers, sorbents and manual recovery.

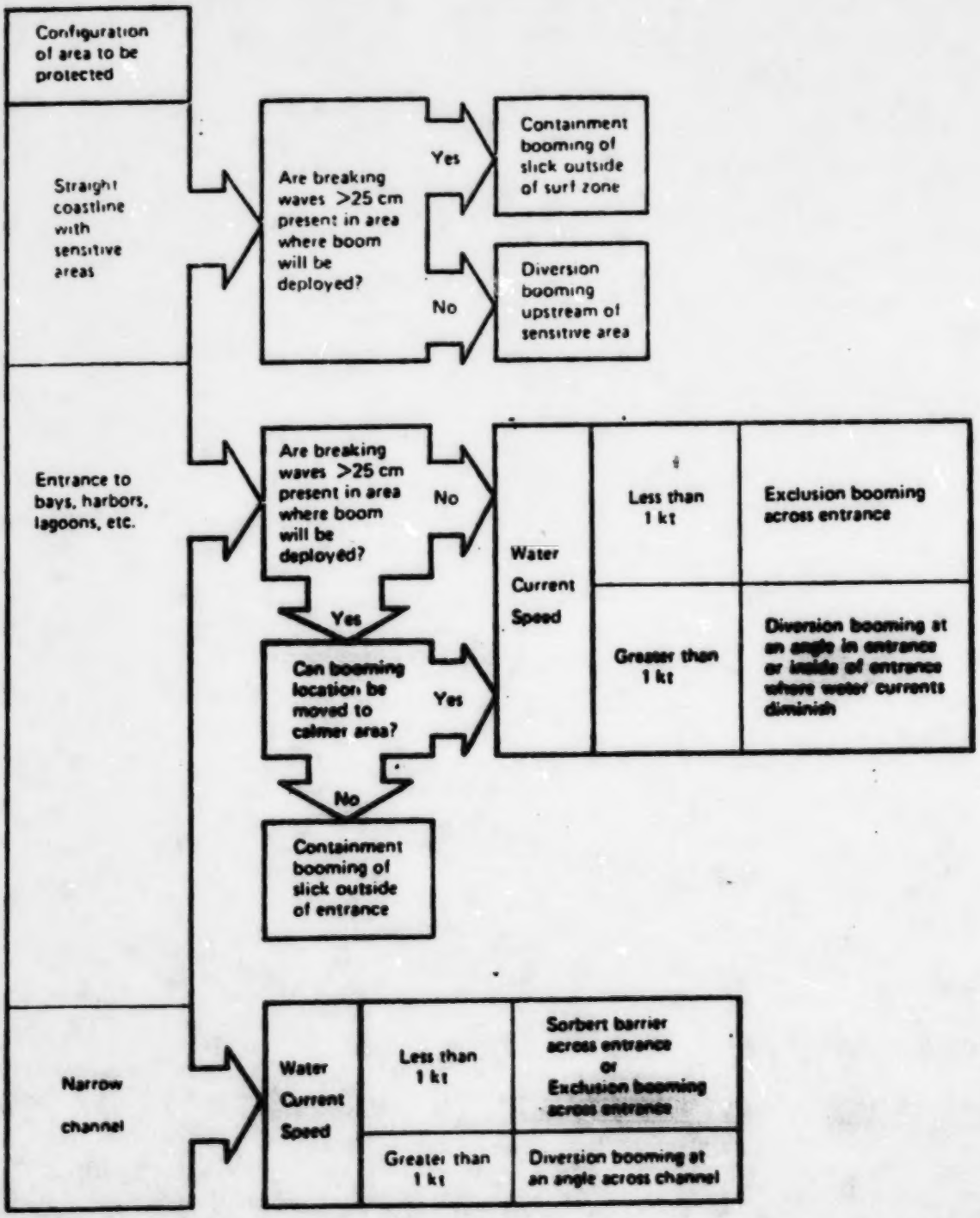
8.1 Skimmers

A skimmer is defined as a "mechanical device designed to remove oil from the water surface without causing major alterations in its physical or chemical properties". (Basics of Oil Spill Cleanup With Particular Reference to Southern Canada. Fingas et al. 1978). They are most often used in conjunction with containment booms that divert the oil towards the skimmer.

In many cases, skimmers would not be practical for use on Lake Superior. Any debris, ice and wave action would reduce the efficiency of many skimmers. Also, extremely heavy oils such as Bunker C which is semi-solid in cold water, are difficult to direct towards a skimmer, thereby reducing effectiveness.

There is a wide variety of skimmers available on the market and many of these are discussed in great detail in A Catalogue of Oil Skimmers, prepared by L.B. Solsberg. This catalogue is available in the Pukaskwa National Park library.

Figure 5. Protection decision guide for coastal waters. (Source: Coastal Environments and the Cleanup of Oil Spills for Inland Waters. Woodward-Clyde Consultants.)


Configuration of area to be protected
Straight coastline with sensitive areas
Are breaking waves >25 cm present in area where boom will be deployed?
Yes
No
Containment booming of slick outside of surf zone
Diversion booming upstream of sensitive area
Entrance to bays, harbors, lagoons, etc.
Are breaking waves >25 cm present in area where boom will be deployed?
No
Yes
Can booming location be moved to calmer area?
Yes
No
Containment booming of slick outside of entrance
Water Current Speed
Less than 1 kt
Exclusion booming across entrance
Greater than 1 kt
Diversion booming at an angle in entrance or inside of entrance where water currents diminish
Narrow channel
Water Current Speed
Less than 1 kt
Sorbent barrier across entrance or Exclusion booming across entrance
Greater than 1 kt
Diversion booming at an angle across channel

8.2 Sorbents

A sorbent is a material which draws oil unto itself. Sorbents are most effective for the clean up of minor oil spills and they are used primarily close to the shoreline.

Three categories of sorbents will be examined. These are natural organic sorbents, mineral based sorbents and synthetic based sorbents.

Examples of natural organic sorbents are peat moss, straw, hay, sawdust, milled corn cob and wood cellulose fibre. Some general characteristics are, they are non toxic, biodegradable, low viscosity oils may drain out of them when they are lifted out of water and some are available in compressed sheet for easier removal after use. Most of the natural sorbents are loose fibres and can be very hard to retrieve.

Inorganic or mineral based sorbents are very light and difficult to distribute when windy, which is often the case along the Park's shoreline. They have the potential to cause respiratory irritations to the cleanup crew and they are also non-biodegradable. Dip nets or similar equipment are needed to recover this type of sorbent.

Examples of synthetic organic sorbents are polyurethane foam, urea formaldehyde foam, polyethylene and polypropylene. These have a comparatively high recovery efficiency and some can also be re-used after oil is squeezed out. They are quite easy to spread and recover and are available in different forms such as sheet, booms and rolls. However, synthetic organic sorbents are relatively expensive and they are not biodegradable which means they must be completely recovered.

A fold out chart, in Appendix IV, compares the advantages and disadvantages of several sorbents which were on the market in the year 1985. The distributors and costs are also provided along with other useful information.

8.3 Manual Recovery

Manual recovery is the most commonly used method of cleanup after an oil spill especially if the oil has reached the shoreline. It is extremely labour intensive. The main limiting factors are the availability of manpower, hand tools and disposal facilities.

8.4 Separation and Disposal

Oil/water separation and disposal were not objectives of this report but some comments should be made. Some water is evidently collected with the recovered oil. One easy way to

separate out the water is to collect the recovered oil/water mixture into a drum or tank with a spigot at the bottom which can be opened in order to drain the water off. As far as disposal is concerned, the government procedures are in Appendix V.

9.0 OTHER TREATMENTS

There are other ways that spilled oil can be treated while it is still on the water in addition to just collecting and disposing of it. The different treatments are dispersants, sinking agents, chemical barriers, burning and wicking agents, gelling agents and biological agents. None have been recommended or approved for use in the Great Lakes due to the facts that they have poor results in cold water and there is too high a risk of serious pollution. Dispersants are especially forbidden in the Great Lakes as they would create too many political problems concerning drinking water supplies.

10.0 METHOD OF ANALYSIS FOR IMPACT

Mr. M. Fingas, Head of Chemistry and Physics, Environment Canada, suggested that chemical analysis for residual and impact levels after an oil spill would be too involved and not very feasible for park employees. This is not to say that the amount of residual impact cannot be determined using other methods. If the necessary benchmarks were obtained for specific shoreline locations beforehand for parameters such as aquatic insects, zooplankton, protozoan and zoobenthos then inventories can be taken at different times after a spill occurs. These can then be compared with the amount that was there before the oil spill occurred.

11.0 RECOMMENDATIONS

11.1 Contingency Plan

The Park should develop a contingency plan specific to oil spill responses along the coastline of Pukaskwa National Park. Appropriate protocol, contact agencies and staff training needs should be identified.

11.2 Small Spills

Small spills, resulting accidentally from staff use of oils such as diesel fuel, gasoline and Jet B, could be handled effectively by Park staff if the Park was prepared ahead of time for such an incident. Several boom logs could be tied together ahead of time and then be tied in the water along the bank of the Pic River at the water intake location ready to contain any small spill, should one occur. Two or three bales of SPC Oil Sorbent Pads, which are suitable for recovering diesel fuel and gasoline could be kept in the butler building as well. Appendix IV contains information on the above mentioned sorbent.

11.3 Large Spills

Although vessels carrying Bunker C and other oils are responsible for the cleaning up their own spills, it is recommended, in the event of a spill off the Park shore, that sensitive priority areas be protected by boom logs (Section 7.2). This could be done by using the Park tug boat if James River - Marathon Limited consented to the use of their log booms, which are presently sitting idle at the mouth of the Pic River. Assistance would also be available from the Canadian Coast Guard Service and technical advice would be available from the Conservation and Protection branch of Environment Canada.

11.4 Skimmers

Due to their potentially high cost and the small chance of benefitting by one, it is recommended, in the event that the Park does want to use a skimmer, that it should be borrowed instead of purchased. The Thunder Bay Canadian Coast Guard Service would be a good contact regarding the use of a skimmer.

In the case of a small Park oil spill, the use of a skimmer would not be recommended as the use of a sorbent would be much more practical and feasible.

11.5 Awareness

If appropriate Park staff members had a basic understanding of the contents of this research paper, in the event of an

oil spill, they would already be one step ahead as far as mitigating the effects of the spilled oil in the environment is concerned. Oil spill awareness could be treated like an environmental first aid course and staff could be briefed once a year on oil spill prevention and mitigation.

11.6 Shoreline Classification

The high priority areas identified on the maps in Appendix I should be enlarged onto the newer Ontario Base Maps which are at a scale of 1:20 000. Then, the priority shoreline sections could be classified even further by shoreline material such as rock, cobble, or sand. This way, the most sensitive areas within a priority area can be identified more easily and a greater effort can be concentrated into protecting these areas from spilled oil.

11.7 Benchmarks

Establish the necessary pre-spill biological benchmarks for specific shoreline locations with regards to aquatic insects, zooplankton, protozoan and zoobenthos.

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APPENDIX I

MAPS SHOWING PRIORITY AREAS

Legend for Location

1 Beach Two
2 Beach One
3 Horseshoe Beach and Area
4 Hattie Cove
5 Playter Harbour
6 Mouth of White River
7 Mouth of Willow River
8 Shot Watch Cove
9 Morrison Harbour (1km N.)
10 Island between Morrison Harbour and Fish Harbour
11 Fish Harbour
12 Oiseau Bay
13 Dampier Cove
14 Nicols Cove
15 Fisherman's Cove
16 Island west of One Lake Island
17 White Gravel River Beach Area
18 White Spruce Harbour
19 Simons Harbour
20 Mouth of North Swallow River
21 Island off Trappers Harbour
22 Triangle Harbour
23 Otter Cove
24 Otter Island and surrounding islands
25 Island off Deep Harbour

O = # 1 priority

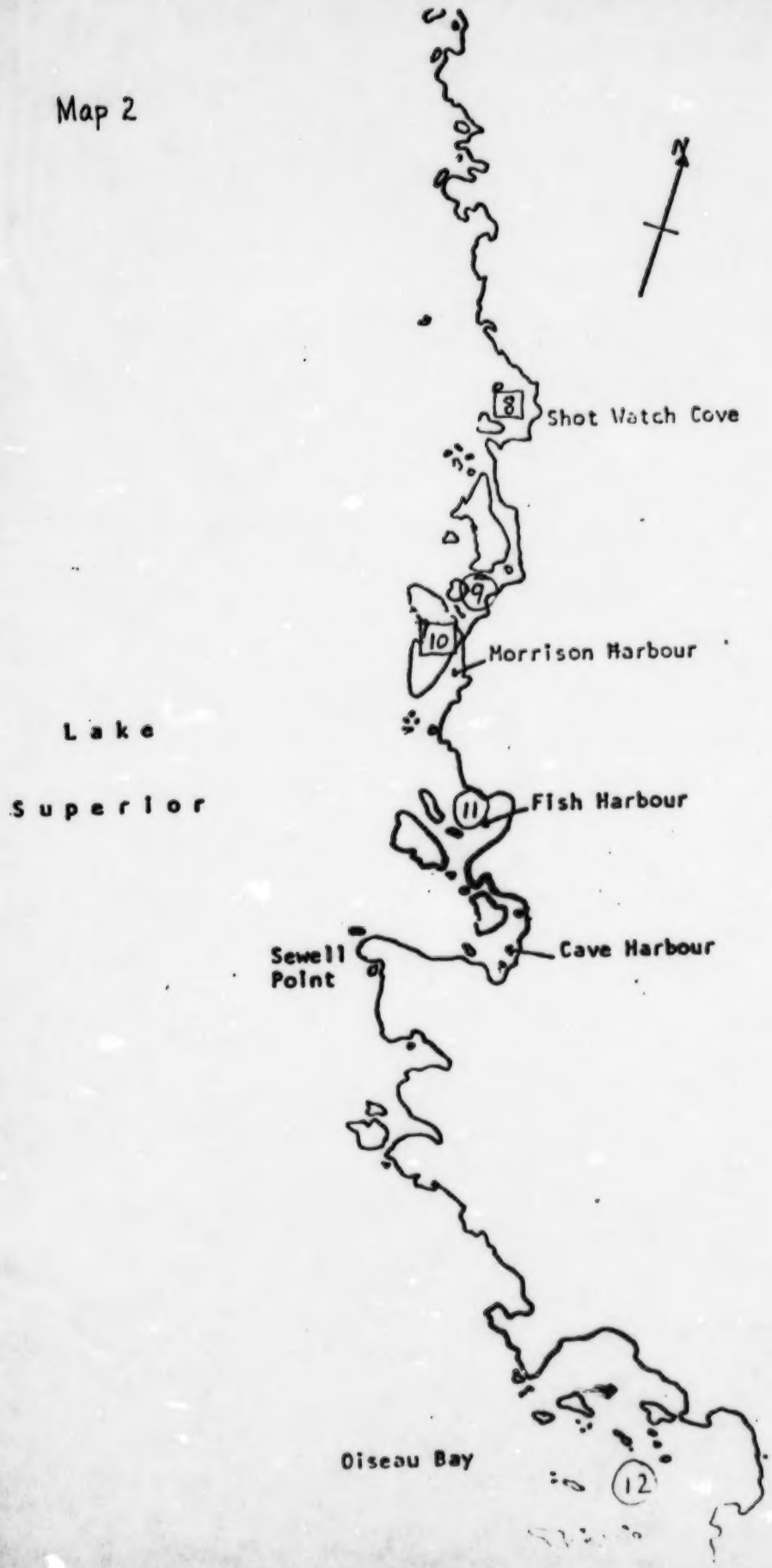
□ = # 2 priority

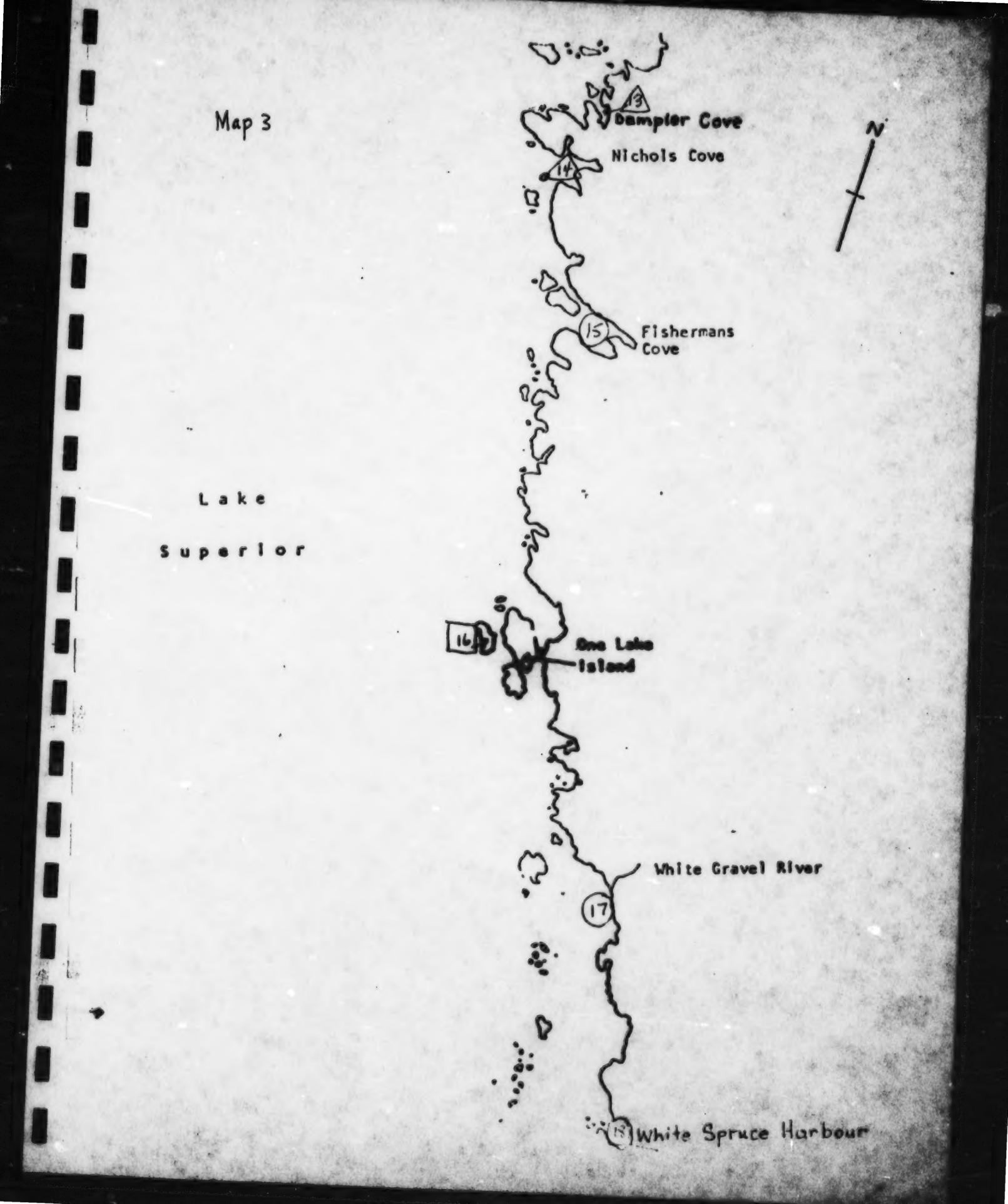
△ = # 3 priority

Map 1

Pic River
1
2
Hattie Cove
3
4
N
Playter Harbour
5
Lake
Superior
White River
6
7

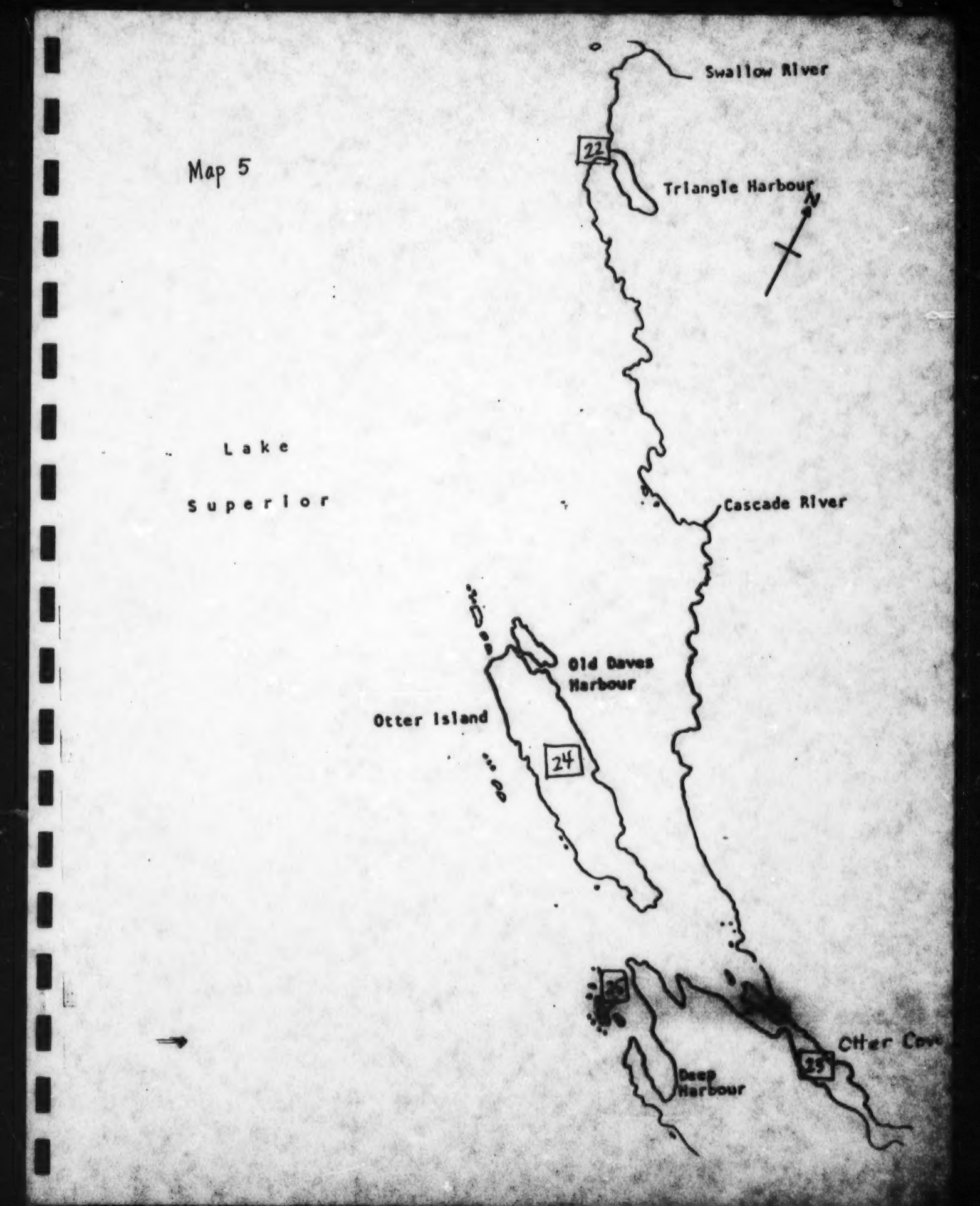
Map 2


N
8
Shot Watch Cove
9
10
Morrison Harbour
Lake
Superior
11
Fish Harbour
Sewell
Point
Cave Harbour
Oiseau Bay
12


Map 3
13
Dampier Cove
Nichols Cove
14
N
15
Fishermans
Cove
Lake
Superior
16
One Lake
Island
White Gravel River
17
18
White Spruce Harbour

Map 4

N
19
Simons Harbour
Lake
Superior
20
North Swallow River
Trappers Harbour
21


Map 5
Swallow River
22
Triangle Harbour
N
Lake
Superior
Cascade River
Old Daves
Harbour
Otter Island
24
25
Otter Cove
25
Deep
Harbour

APPENDIX II

THE IMPACT AND PERSISTENCE OF STRANDED OIL

(Source: Coastal Environments and the Cleanup of Oil Spills for Inland Waters. Woodward-Clyde Consultants.)

The Impact and Persistence of Stranded Oil

SHORELINE TYPE	IMPACT OF OIL	PERSISTENCE
Coasts Without Sediment		
ROCK MAN-MADE	• oil may be reflected • coats exposed dry surfaces • wave splash can throw oil above normal limits of wave action • oil does not easily adhere to wet surfaces • thickness of oil cover decreases as steepness increases • oil collects in rock pools	• oil readily abraded if it is stranded below normal limit of wave activity, except in sheltered sites
Coasts With Sediment		
MUD	• mud has very small spaces between particles and these are usually filled with water, therefore, only very light grades of oil penetrate	• muds are easily transported by waves, therefore, oil can be buried • buried oil degrades very slowly in muds • surface oil may be easily removed by waves because water usually separates the oil from the mud
SAND	• only light oils can penetrate sand • heavy oils rarely penetrate more than 2 to 3 cm • penetration depths are greater during periods of high temperatures • oil is usually deposited at upper limit of wave action	• oil can be easily abraded if it is not buried and if it is within the zone of wave action • possibility of burial is high if beach is subject to wave action during storms • oil/sediment may form an "asphalt pavement", thereby increasing persistence
PEBBLE COBBLE BOULDER	• as the size of the sediments increases, the depth of penetration of all oils increases • penetration of medium and heavy oils can be as much as 1.0 m • light grades of oil may be washed through the beach and flushed by waves	• buried oil and "asphalt pavements" are very persistent • surface oil is easily abraded by waves and moving sediments
MIXED SEDIMENTS	• spaces between larger particles are filled with smaller-sized sediments, therefore, oils rarely penetrate (except light grades)	• usually low energy environments, therefore, even surface oil persists • "asphalt pavements" are common

APPENDIX III

A PROCEDURE FOR CLEANING OILED BIRDS

A PROCEDURE FOR CLEANING OILED BIRDS
(Source: Oil Pollution of Birds: an Annotated Bibliography. Hooper, t.d. et al. 1987.)

1. Before transporting oiled birds to cleaning centre, feed them fish while keeping them warm in a dry cloth poncho.

2. Pack the birds loosely in ventilated cardboard boxes for the transportation. Rehabilitation of the strongest birds is the priority.

3. When the birds are alert and able to stand, wash them in a 1% solution of household detergent and water at 40-45°C. Thoroughly wash and rinse. Residual oil and detergent destroys the water repellency of feathers.

4. Birds will recover strength if dried and kept warm and on a diet of fresh or frozen fish.

5. Water repellency is regained if birds are allowed to bathe and preen in an environment free of dirt and contaminants.

6. In two to three weeks, the strong and healthy ones can be released. They should be tagged in order to evaluate progress.

For further advice contact:

Jenette Perkins
Biologist
Canadian Wildlife Service
1325 Woodward Drive
Ottawa, Ontario
K1G 3Z7
(613) 952-2299

APPENDIX IV

FOLD-OUT CHART COMPARING SORBENTS

APPENDIX V

SAFETY PROCEDURES FOR PETROLEUM PRODUCTS

(Source: Code of Good Practice for Management of Hazardous and Toxic Waste at Federal Establishments. Environment Canada. 1977. p. 133.)

SAFETY PROCEDURES	PETROLEUM, OILS AND LUBRICANTS (POL) WASTES	NOTE/WARNING
Handling		Keep all open flames or potential sources of sparks remote from oils which are heated close to their flash points
Fire Extinguishing	Use CO_2 extinguisher or water spray for	
	DISPOSAL/RECOVERY	
One of the following procedures should be used:		In emergencies contact E.P.S. prior to use of one of the following procedures
1. Thinners, hydraulic fluids and oils: send to recovery companies where feasible (see Section 5)		1. Incinerate using low temperature incineration.
2. Recover heat value by incineration in boiler (see Section 5).		2. Spray oils on roads for dust abatement where hazardous impurities (e.g. tricresyl phosphate) are absent. Must conform with local by-laws.
3. Incinerate using commercially available incinerators designed to burn flammable liquid wastes, meeting air quality standards.		3. Use suitable oils (as in 2 above) for road stabilization.
3. Send to industrial waste disposal firm for disposal.		

APPENDIX VI

GLOSSARY

GLOSSARY

Access - Ability to approach or enter.

Adrenal hypertrophy - An increase in adrenal gland size.

Aromatic hydrocarbon - A hydrocarbon characterized by the presence of atleast one benzene ring.

Catalytic cracking - The breaking up of chemical compounds in the presence of a catalyst.

Crenulation - The process of obtaining a wavy outline.

Cytoplasmic density - Matter per unit volume of protoplasm surrounding the nucleus within a cell.

Dissolution - The act ot process of dissolving.

Diversion booming - Booming in such a way as to divert oil away, with the aid of water currents, from certain areas.

Emulsification - The process whereby one liquid is dispersed into another.

Wave energy level - The level of wave action acting against a shoreline.

Exclusion booming - Using booms as a barrier across an area such as an inlet to a bay or cove.

Exposure - The condition of being unprotected or unsheltered from elements such as wind and waves.

Fractional distillation - The separation of a mixture of liquids such as crude oil into compounds having different boiling points.

Flash point - The temperature at which vapours of a petroleum product will ignite when exposed to an ignition source such as an open flame.

Histological - Pertaining to tissues.

Hydrocarbon - An organic compound containing only hydrogen and carbon atoms.

Hyperphagia - Excessive initake of food.

Intestinal mucosa - Intestinal mucous membranes.

Mitochondrion - A cellular organelle that is important in the metabolic activities of cells.

Necrosis - The pathologic death of cells or tissues, especially those associated with living cells.

Olfactory - Anything pertaining to the sense of smell.

Oxidation - A reaction in which oxygen combines with another substance with the liberation of heat.

Persistence - The action or fact of persisting.

Plasma membrane - The membrane that holds a cell and its contents together as one unit.

Pour point - The lowest temperature at which a substance will flow.

Renal - Pertaining to the kidneys.

Shoreline sensitivity - How sensitive a shoreline is to the effects of oil, related to persistence.

Solubility - The capability of going into solution.

Specific gravity - The ratio of the weight of a substance to the weight of an equal volume of water.

Substrate - Materials which form the base of something.

Surface tension - The force of attraction between the surface molecules of liquid.

Unique features - Special features that are distinctly characteristic and as a result warrant special consideration.

Viscosity - The property of a fluid by which it resists a change in shape, or movement.

EFFECTIVE: June 1985 (Source: Selection Criteria and Laboratory Evaluation of Oil Sorbents Update III. Enviroclean. 1985.)

SORBENT	TYPE	HOW SOLD	DISTRIBUTOR	COST	BULK DENSITY	AVERAGE PICK-UP by weight
Seaclean	natural (feathers)	45 x 45 x 7.5cm pillows	Sean Clean Inc. 7000 SW 62 Ave. Suite 555 Miami, FL 33143	U.S. $3.75/pillow	14 kg/m³	1:3-
Conwed Sorbent Blanket	water resistant mat, natural fibres reinforced with polypropylene mesh	rolls (89 x 6100cm)	CIL Inc. P.O. Box 836 Edmonton, Alta T5J 2L4 (403) 465-0221 CIL Inc. 2900 Jean Baptiste Deshamps Blvd. Lachine, Que. (514) 636-4730	$145.00/roll	59 kg/m³	1:18
Verdyol	specially treated vegetable fibres	30kg bales 2m wide matting	Verdyol Plant Research Ltd. R.R.#1 Cookstown, Ont. L0L 1L0 (416) 458-9601	$0.50/kg	300 kg/m³	1:13-
AB&B Pads	polypropylene fabric	pads	American Boom and Barrier P.O. Box 933 Port Canaveral, FL 39320	NA	NA	1:3-
Alsorb	polypropylene fabric	rolls (45m x 1m x 5mm) sweeps (3m x 1m x 5mm) pads (46 x 46 x 0.5cm) booms (3m)	Colonial Marine Ind. Corp. P.O. Box 278 Port Colbourne, Ont. L3K 5W1	rolls $175.00 ea. sweeps $135.00/bale of 15 pads $104.00/bale of 100	NA	1:9-
Conwed D-Sorbent Pads	closed cell polypropylene foam	pads (53 x 53 x 0.6cm)	CIL - same addresses as above	$95.00/80 pc. carton	38 kg/m³	1:23
Graboil	treated polyurethane foam	batts, rolls, booms packed in 0.25m cardboard boxes	R.B.H. Cybernetics P.O. Box 4205, Stn. A Victoria, B.C. V8X 3X8	batts $109.60/pkg. -50 pc. (60 x 30 x 2.5cm) mats $109.60/pkg. -2 pc. (15.25m) boom $133.10/pkg. -4 pc (30.5m)	19 kg/m³	1:23-
Spill Control Co. PEP Pads	polyether base	pads	Spill Control Co. Sorbent Sciences Div. 828 North Grand Ave. Covina, CA 91724	NA	NA	1:10-
Spill Control Co. SPD Pads	polyester	pads	Spill Control Co. same as above	NA	NA	1:5-1
SPC Oil Sorbent Pads	polyethylene fabric	pads booms pillows sweeps blankets particulates	Sorbent Products Co. Inc. 901 Charlesworth Dr. Sarnia, Ont. N7U 2S2	46 x 46 x 1cm pads (bale/100) $117.00 46 x 46 x 0.5cm pads (bale/200) $117.00 91 x 91 x 1cm pads (bale/50) $234.00 3 x 25cm dia. boom (pkg./4) $272.00 3 x 12.5cm dia. boom (pkg./4) $157.50 36 x 63cm pillows (pkg./10) $150.00 30m x 48cm sweep (ea.) $135.00 46m x 91cm blanket (ea.) $191.00	40 kg/m³	up to
3M Type 156 Pads	polyethylene fabric	sheets	Anco Chemicals Ltd. P.O. Box 400 Maple, Ont. L0J 1E0	46 x 46 x 1cm (bale 100) $122.35	48 kg/m³	1:14-1
Olcansorb	treated natural peat fibre	loose fibre	Terra Nova Power & Dev. Ltd. P.O. Box 13531 St. Johns, Nfld. A1B 4B8 (709) 753-9043	$3.30-$3.85/kg (depends on quality)	288 kg/m³	1:5, 8-

	COST	BULK DENSITY	AVERAGE OIL PICK-UP RATIO sorbent:oil by weight	REUSEABILITY	SPILL TYPE	EQUIPMENT REQUIRED	DISPOSAL	TOXICITY
	U.S. $3.75/pillow	14 kg/m³	1:3-1:6	variable (3-6)	all types and weights good in swells and high winds	manual labour boat hook pitch fork	incineration landfill	none
aptiste d. 30	$145.00/roll	59 kg/m³	1:12-1:14	none	bunker fuels	manual labour	incineration landfill	nontoxic biodegradable
	$0.50/kg	300 kg/m³	1:13-1:19	none	no. 2 oil to Bunker C	blower, fishing net or skimmers	incineration landfill	nontoxic biodegrad
	NA	NA	1:3-1:6	reuseable	lighter oils	NA	NA	NA
	rolls $175.00 ea. sweeps $135.00/bale of 15 pads $104.00/bale of 100	NA	1:9-1:16	none	heavy oils	manual labour	incineration	nontoxic
	$95.00/80 pc. carton	38 kg/m³	1:23	reuseable	most oils	manual labour wringer	incineration landfill	nontoxic
	batts $109.60/pkg. -50 pc. (60 x 30 x 2.5cm) mats $109.60/pkg. -2 pc. (15.25m) boom $133.10/pkg. -4 pc (30.5m)	19 kg/m³	1:23-1:33	reuseable	light to heavy oil	manual labour air deployable	landfill incineration	nontoxic
	NA	NA	1:10-1:30	reuseable	diesel oil and gasoline	manual labour	recycling burial incineration	nontoxic
	NA	NA	1:5-1:10	reuseable	sand surfaces shallow water heavy oil	manual labour	recycling burial incineration	nontoxic
	46 x 46 x 1cm pads (bale/100) $117.00 46 x 46 x 0.5cm pads (bale/200) $117.00 91 x 91 x 1cm pads (bale/50) $234.00 3 x 25cm dia. boom (pkg./4) $272.00 3 x 12.5cm dia. boom (pkg./4) $157.50 36 x 63cm pillows (pkg./10) $150.00 30m x 48cm sweep (ea.) $135.00 46m x 91cm blanket (ea.) $191.00	40 kg/m³	up to 1:13	very reuseable	gasoline diesel oil	manual labour	incineration to <0.2% ash	nontoxic
	46 x 46 x 1cm (bale 100) $122.35	48 kg/m³	1:14-1:22	very reuseable	rainbow sheens of fuel oils gasolines to motor oil	manual labour	incineration to <0.1% ash	nontoxic
	$3.30-$3.85/kg (depends on quality)	288 kg/m³	1:5, Bunker C lower due to recovery problems	none	fresh heavy oil bays, beaches, harbours	manual labour suction skimmers	burial burning	nontoxic